SHIP PRODUCTION COMMITTEE
FACILITIES AND ENVIRONMENTAL EFFECTS
SURFACE PREPARATION AND COATINGS
DESIGN/PRODUCTION INTEGRATION
HUMAN RESOURCE INNOVATION
MARINE INDUSTRY STANDARDS
WELDING
INDUSTRIAL ENGINEERING
EDUCATION AND TRAINING

September 1982
NSRP 0009

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

Proceedings of the IREAPS Technical Symposium

Paper No. 18: Productivity Improvement in Shipyard Steel Fabrication Through Integrated Material Handling Technology

U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **SEP 1982**	2. REPORT TYPE **N/A**	3. DATES COVERED **-**

4. TITLE AND SUBTITLE
The National Shipbuilding Research Program, Proceedings of the IREAPS Technical Symposium Paper No. 18: Productivity Improvement in Shipyard Steel Fabrication Through Integrated Material Handling Technology

5a. CONTRACT NUMBER
5b. GRANT NUMBER
5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

5d. PROJECT NUMBER
5e. TASK NUMBER
5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Surface Warfare Center CD Code 2230 - Design Integration Tools Building 192 Room 128-9500 MacArthur Blvd Bethesda, MD 20817-5700

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**SAR**	**16**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

DISCLAIMER

Proceedings
IREAPS Technical Symposium
September 14-16-1982
San Diego, California

VOLUME I

INSTITUTE FOR RESEARCH AND ENGINEERING FOR AUTOMATION AND PRODUCTIVITY IN SHIPBUILDING

I R E A P S

PRODUCTIVITY IMPROVEMENT IN SHIPYARD STEEL FAERICATION THROUGH INTEGRATED MATERIAL HANDLING TECHNOLOGY

Steiner Draegbo
Vice President and General Manager
Total Transportation Systems Incorporated
Newport News, Virginia

TTS is a company specializing in custom-designed material handling and production systems for shipyards worldwide. Before joining TTS in early 1982, Mr. Draegebo was General Manager of New Construction at Halifax Industries' shipyard in Halifax, Nova Scotia, and prior to that he held several senior technical, production planning, and marketing positions with Davie Shipbuilding Limited in Quebec, Canada. Mr. Draegebo's early career in the Norwegian shipbuilding industry included three years as a consultant with Shipping Research Services of Oslo, Norway.

Mr. Draegbo is a graduate in naval architecture and marine engineering from the Technical University of Norway.

Frank E. McConnell
Vice President
Total Transportation Systems Incorporated
Newport News, Virginia

Prior to 1979 when Mr. McConnell joined TTS as Vice President, he worked as a consultant in the field of shipyard management and facilities development. He has earlier managed the Program Planning and Manufacturing Engineering groups at Ingalls Shipbuilding, and was for several years associated with General Dynamic's Electric Boat Division.

Mr. McConnell has a BSME degree from Lehigh University and is a former member of the SNAME Ship Production Committee.

ABSTRACT

A significant portion of shipyard steelwork can be mechanized through introduction of modern production line technology. The productivity improvements on such lines arise principally from more efficient material handling and a corresponding reduction of time lost between operations. Panel lines are undergoing exiting developments and are being installed even in very small shipyards. Efficient and affordable web line and beam line technology is now available but not yet adopted by shipyards in the United States.

1. INTRODUCTION

Before adressing how production lines and other in-process material handling applications impact shipyard productivity, it is interesting to explore which portions of the total shipbuilding effort we are dealing with.

As any student of shipbuilding productivity will know, recorded manhour expenditures and cost data are generally not published, and very little material is therefore available on this subject. Furthermore, differences in cost recording practises, etc., make inter-company comparison difficult even if figures are obtained.

It is therefore with some caution that the authors have analyzed manhour expenditure records from a sample of medium-sized shipyards, and are presenting judiciously averaged percentages in figure 1. The data relate to 25 - 40,000 tdw product carriers and bulk carriers, plus to large offshore supply vessels. The shipyards in question are "conventional", i.e. non-mechanized. Steelwork (accounting for approximately 45% of the total "direct" manhours) includes all structural steel with deckhouses and superstructure but excludes outfit steel and castings.

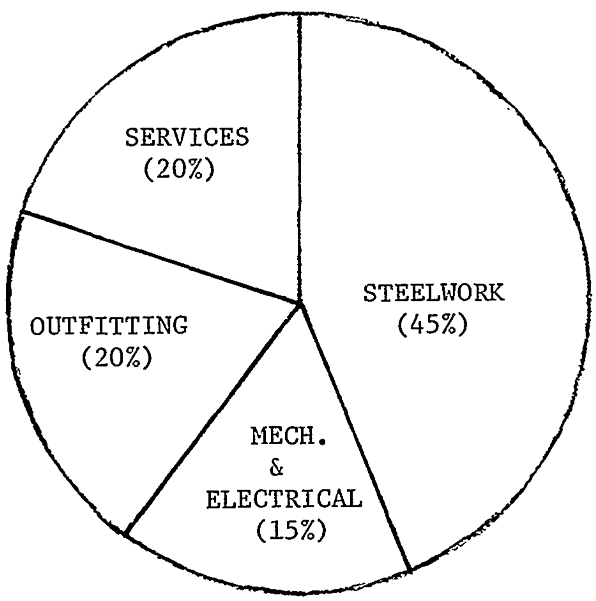

Fig. 1. Break-down of Total Ship Production Manhours

A further break-down of the steelwork manhours is indicated in figure 2. Based on our sample figures, we find that approximately 5% of the steelwork hours are spent on marking and cutting (prior to assembly), 30% on welding, and the remaining 65% on platework (i.e. fitting and tack welding) plus miscellaneous activities such as frame bending, rolling, pressing, grinding, stockyard manipulation, etc.

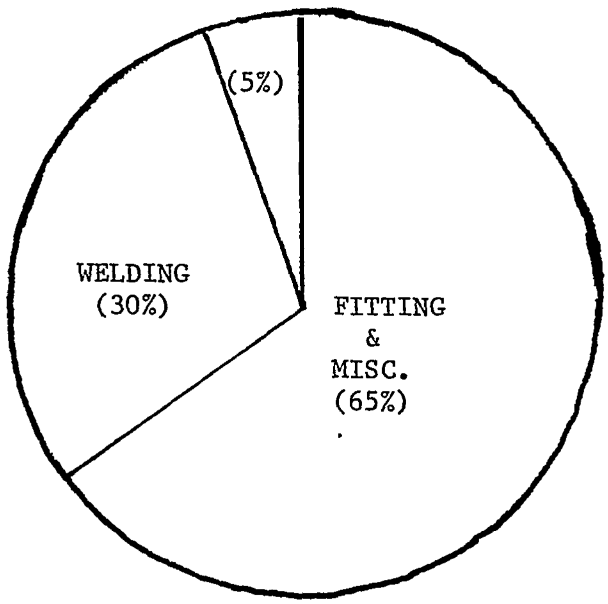

Fig. 2. Break-down of Steelwork Manhours

We may throw further light on the subject by refering to research done by the Norwegian Ship Research Institute in cooperation with a group of shipyards (ref. 1). After analyzing several sizes and types of vessels, the Institute established that 40 - 75% of the total steelweight lends itself to mechanized line production. The portion naturally depends on the type of ship and can be significantly increased by designing the ship to suit the facilities.

Figure 3 introduces a different and more controversial breakdown of the steelwork manhours mentioned above. We postulate that in an "average" shipyard less than 50% of the steelwork manhours are actually spent on bona fide production activities, with the balance going mainly to in-process transportation and operator waiting time (including time spent on moving and mobilizing people, transporting tools, bringing material to and from the various worksites, waiting for cranes, preparing fixtures, waiting for instructions, interference between activities, etc.).

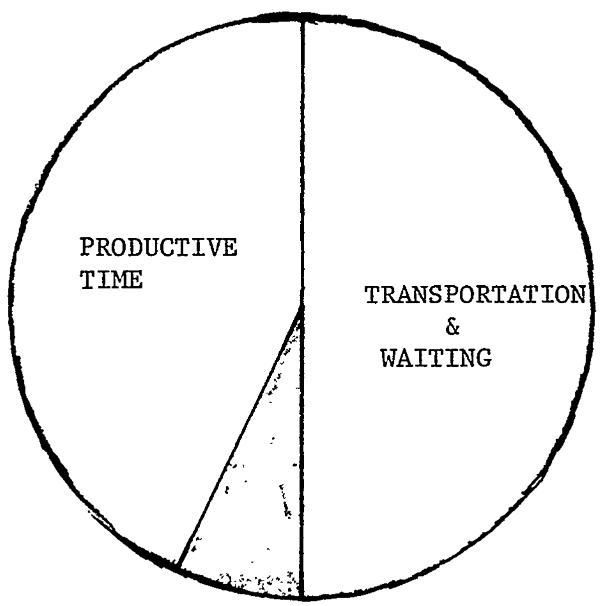

Fig. 3. Steelwork Manhours shown as Productive and Unproductive Time with a "Grey Area".

This situation is not evident from conventional cost records. A tradesman's time is routinely charged against a job number and sometimes also against a unit or zone number as time worked whether he waits in line at the tool crib, walks from one jobsite to another, waits for a crane, or actually works.

Normally only time lost due to significant and lengthy interruptions (like power failure) would be recorded as waiting time. Except for trades like welders (where arc time can be accurately and impartially measured) getting a true picture of the productive work time requires the use of time study methods.

As our abovementioned postulation (that less than 50% of the steelwork manhours are spent productively) is not based on a body of scientific data, we invite the audience's comments on this matter during the discussion period. We would like to mention, however, that production staff at numerous shipyards almost unanimously have accepted our postulation and in fact in many instances have pointed out that the situation is worse than we claim.

The balance of this paper analyzes the application of production line material handling technology to efficiently bring together material, tools and people to reduce the unproductive time described above.

2. TRADITIONAL SHIPYARD PRODUCTION LINES

The most widely adopted application of production line technology within the shipbuilding industry is in-line fabrication of stiffened steel panels. As will be discussed later, most existing panel lines are not primarily improving the production processes per se, but are tremendously reducing unproductive time between these processes by rationalizing the handling and transportation of material between organized work stations.

In principle, a panel production line consists of a floor-mounted conveyor system or roller bed along which is arranged a number of work stations specially designed, equipped and manned for the individual operations required to produce a stiffened panel. The width of the floor-mounted roller bed is normally equal to the widest panel which will be made on the line (normally 30 - 60 ft.), and the length of the line (normally 150 - 500 ft.) depends on the number of work stations and the degree to which the panels are completed on the line.

The conveyor system or roller bed is arranged with suitable drive mechanisms to advance the panels from one work station to the next, and normally equipment for mechanically manipulating, aligning and turning the panels are built into the roller bed.

Typical work stations are:

- aligning, fitting and tack welding of plate butts
- butt welding (normally with submerged arc equipment)
- turn-over of plate blankets (except for lines using one-side butt welding equipment)
- marking and edge trimming
- stiffener fitting and tacking
- stiffener fillet welding
- web fitting and tacking
- web welding
- preoutfitting.

No panel lines will have all these stations, and some stations may be arranged for more than one function depending on product mix and capacity considerations. Obviously, the more complete the panel can be made on a panel line the more efficient the total production will be.

Panel production lines have been around for a long time, in fact, one of the earlier US patents within this area was issued to Sun Shipbuilding of Pennsylvania in 1932. However, widespread introduction of panel lines generally took place in the 1960's as shipyards, particularly in Europe and Japan, were constructed or expanded to meet the steadily increasing demand for larger and larger oil tankers.

The three or four standard makes of panel lines which competed commercially to meet this demand all represented major improvements from the conventional assembly techniques. They provided the yards with well-organized work stations and a superior material flow with much less dependence of overhead cranes.

Generally, the panel lines of the 60's and early 70's were characterized by:

- massive structures with fixed work stations
- two-side butt welding of plates, even though some one-side welding methods were introduced
- stiffener infeed from the side, generally through elaborate bridge structures with hydraulic clamping devices
- no special tools for web fitting and welding
- relatively high cost.

Some of these characteristics may today seem less than desirable, but for the emerging builders of VLCC's and ULCC's the new technology was ideal and contributed significantly to the dramatic increase in productivity of building of large tankers and bulk carriers. However, panel lines were generally not introduced in other than the largest yards, and were in fact considered suitable only for high volume production.

3. "STATE OF THE ART" OF THE PANEL LINE TECHNOLOGY

The dramatic change of the shipbuilding scene in the mid-1970's had a fundamental impact on the panel line technology. Generally, the suppliers of panel lines were faced with the following situation:

- an abrupt halt in the development of new large shipyards (with a few exceptions in places like South Korea and Brazil).
- a realization in the industry that the period of building very large ships had temporarily come to an end, and that future shipbuilding orders would probably not be for long series of sister ships
- several shipyards switched their attention to the off-shore industry or concentrated on building special type vessels.

While these difficult times for the shipbuilding industry meant equally difficult times for the panel line suppliers, they also presented a tremendous opportunity and challenge: Medium-sized and small shipyards had to improve their productivity to survive in a shrinking market where they were now suddenly competing with the large yards. To do so, they needed to mechanize their material flow and production methods.

In response to these needs, the panel line technology has been developed further over the last few years, in the following directions:

- much more flexible equipment, in two respects:
  - i) adaptable to existing buildings (previously this consideration was less important, as most panel shops were designed around a new panel line)
  - ii) adaptable to a wide range of vessels
- lower acquisition and installation cost
- higher productivity.

Technically, these developments have been achieved through the following means:

- more common use of one-side butt welding. Not having to turn the panels for back welding reduces the length of the panel line and eliminates the need for a special panel turning crane (which requires a high bay locally over the turning station). It also eliminates time-consuming back-gouging and back welding processes.
- more flexible work stations allowing an operation to take place in several locations along the line

- in-line stiffener infeed
- equipment for fitting and welding webs and minor bulkheads is incorporated into the line
- the panel line is to a greater extent integrated into the upstream and downstream material flow
- adaptation of mobile jigs allowing curved panels (with sweep and camber) to be assembled on a panel line
- special panel lines developed for high-volume barge yards.

These developments, together with the competitive forces in the market place, have seen panel lines introduced into many medium sized and small shipyards over the last few years. In fact, the authors' company has installed *a* panel line in a shipyard with only 60 employees and an annual production of about 1.5 small vessels (trawlers or ferries).

4. CURRENT DEVELOPMENTS

"Survival of the fittest" means higher productivity, so present developments of the panel line technology is concentrated on even further reductions of the numbers of operators needed to produce a panel. Some examples:

- development of *a* one-man-operated one-side welding station where advanced fixturing devices eliminate the need for fitting and tacking of the butts prior to welding
- development of a fully automatic one-side butt welding station with unmanned plate infeed and outfeed. So far, this equipment is designed for non-code welding. Continuous through-the-arc welding parameter control equipment now becoming available may eliminate the need for constant operator presence for high quality shipyard butt welding as well.
- use of robots on the panel line.

5. OTHER PRODUCTION LINE APPLICATIQNS

While panel lines represent the most accepted way of mechanizing shipyard steel production, the return on invested capital is probably even greater for beam (shape) lines and web lines, even though these installations are less known, particularly in this country.

In November of 1981, MarAd released an excellent report on a beam-line feasibility study undertaken in cooperation with Avondale Shipyards (Ref. 2). The report concludes that proven beam-line technology is available today for any US shipyard willing to improve productivity and it predicts very impressive savings compared with present manual methods.

As with panel lines, the principle behind both web lines and beam lines is to eliminate costly transportation and waiting time through introduction of rational material handling technology. The work pieces are brought to well-designed work stations, and the operators and their equipment remain stationary.

To illustrate what a modern beam line can do, we can mention that at a medium-sized shipyard (about 20,000 tons of steel a year), it reduced the number of workers transporting, marking and cutting shapes from 17 to 5, principally through mechanization of the shape infeed and outfeed process. However, some of the savings were also obtained in the production process itself by arranging the burning tables for cutting of up to four shapes at the same time with a single-operator burning machine. Marking of the shapes *was* completely eliminated (except identification marking) by introducing a digital indexing system for positioning of the burning torches. See figure 4.

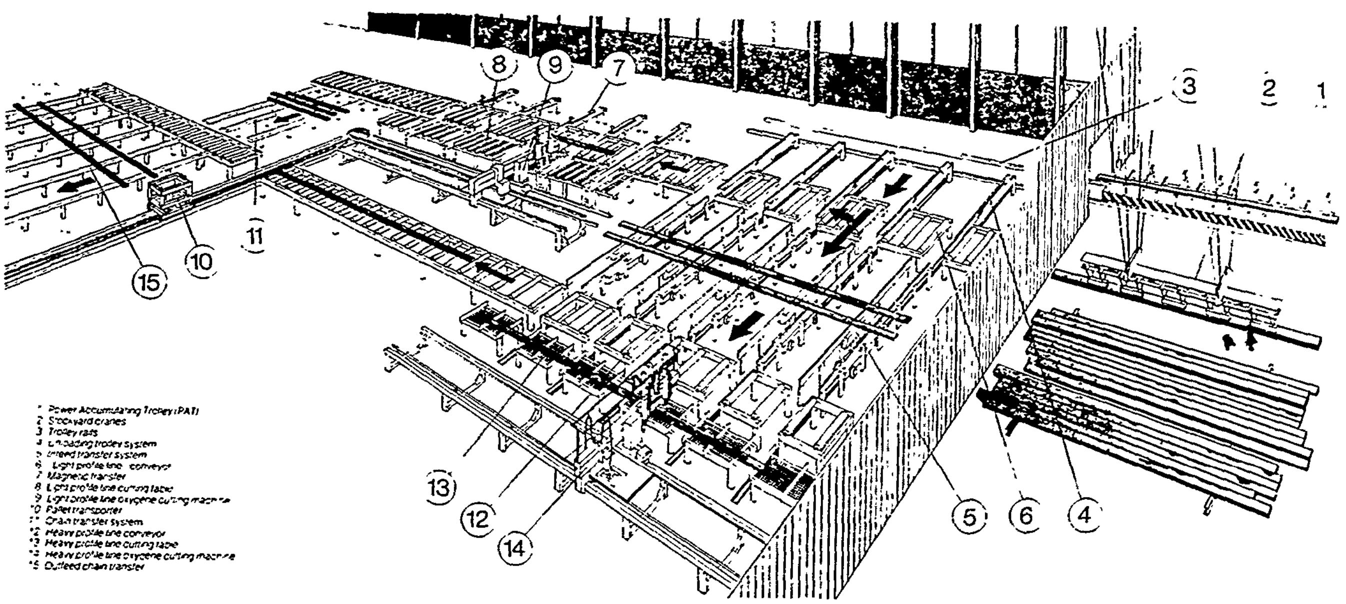

Fig. 4. Schematic View of the Beam Line Installation at the Horten Yard in Norway.

It is also worth noting that the few remaining operators were working under much more pleasant and safer conditions than previously, and that valuable shop space was released for other production.

The authors' organization is currently working with a US robot manufacturing company to develop *a* robot-operated beam line with plasma cutting equipment for a major East Coast shipyard. This project will further enhance the beam line technology, and we look forward to be able to report on the results of this development to the shipbuilding community in a not too distant future.

6. A SYSTEMS APPROACH

To maximize the benefit of any shipyard production line, it is important to regard the line as an integrated part of the total production system. The yard should carefully study its overall production capabilities to ensure that the selected production line equipment is compatible with other equipment. For example, one-side welding techniques are generally sensitive to the plate edge quality and require the use of an N/C burning machine or a high-quality flame planer to achieve the required results. Thus, a yard without adequate facilities for achieving good plate edge quality should opt for a less sophisticated welding technique.

For panel lines, it is also important to ensure that downstream transportation facilities are adequate to allow the fullest extent of panel assembly and possibly pre-outfitting prior to moving to the block assembly or hull erection areas.

The principle of integration of the production lines into the total yard system also.extends to technical information and the production planning and control routines. For instance, successful operation of a panel line requires a detailed plan for panel sequencing and manpower loading per work station, and of *course* subsidiary schedules for plate cutting, stiffener preparation, etc. Furthermore, technical information should be presented in a form suitable for the operators on the individual work stations. This latter task is easily achieved in yards where ad hoc information can be extracted from *a* hull data base whereafter dimensions and instructions needed by the respective operators can be added.

7. CONCLUSIONS

In the introduction of this paper, the relative importance of steelwork in the total cost of certain commercial vessels was discussed. The production line methods described in the foregoing can to varying degrees be applied to the total steelwork, but in all instances the savings potential is significant.

With a modem panel line, a theoretic productivity of 1.5 - 2 manhours/ton is normal (for fitting and completely welding an average panel with stiffeners and webs). The degree to which this target productivity is actually realized depends largely on the ability of the individual organizations to fully gear their production routines, technical information and planning methods to the new hardware. As with any new equipment and methods, there are success stories and also less successful implementations.

The actual savings compared to conventional methods vary from user to user, but as an indication it can be predicted that a panel line installation will pay for itself in about a year provided it can operate steady on a one-shift basis. Savings due to web lines and beam lines are even more difficult to measure. However, the MarAd report (ref. 2) mentioned previously projects a labor savings of 78.3% through shipyard application of a beam line.

However, most impressive is the fact that productivity improvements arising out of the described production line technologies are not due to anyone working harder and only partly due to more effective process equipment. Basically, the benefits come from common-sense material flow which allows each operator to function effectively with a minimum of time lost for reasons beyond his control.

REFERENCES

1. The Norwegian Ship Research Institute (NSFI), Report R-55.76, Oslo, Norway, 1976.

2. US Department of Transportation/Maritime Administration, in cooperation with Avondale Shipyards, Inc.: Beam-line Feasibility Study, November 1981.

Additional copies of this report can be obtained from the
National Shipbuilding Research and Documentation Center:

http://www.nsnet.com/docctr/

Documentation Center
The University of Michigan
Transportation Research Institute
Marine Systems Division
2901 Baxter Road
Ann Arbor, MI 48109-2150

Phone: 734-763-2465
Fax: 734-763-4862
E-mail: Doc.Center@umich.edu